DOUBLE USE OF THE TERM ACCELERATION

To the Editor of Science: Dr. Hering's letter in the issue of October 24 raises a question of scientific terminology of a kind not altogether unusual. He contends that the term "acceleration" is used in one sense by the engineer, namely, to signify the rate of change of speed; and indiscriminately, in two different senses by the physicist, one of these meanings coinciding with the engineering usage, and the other conflicting with it. This second use of the word is to denote the vector rate of change of another vector, the velocity. As I understand his letter, he proposes that the physicist abandon this second meaning in favor of the first.

Dr. Hering is an eminent engineer, and I leave it to other engineers to question, if they choose, his right to speak for them. I must protest however, against his version of the views of physicists. The term acceleration, in its strict sense, is now used by physicists only with the second of the two above meanings, and then applies, when used without any qualifying word, only to the motion of a point or particle. The word is sometimes used, in order to avoid circumlocutions, to denote merely the scalar magnitude of the vector. The need of a new word to express this second notion, in the manner in which we now customarily distinguish between velocity and speed, has long been felt. This somewhat loose usage is however quite different from the definition recommended by Dr. Hering, which would give it the meaning "tangential component of the acceleration." It would be rash to assert that the term is never used in this sense by physicists, for carelessness of language is hard to avoid, but few would be found to defend the usage.

Dr. Hering chooses as an illustration of the divergents of physicist and engineer:

> . . . the revolution of a fly-wheel at a constant speed, the rim of which to the physicist is being constantly accelerated while to the engineer there is no acceleration, as the speed is constant.
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> The physicist argues, and quite correctly, that a moving body represents a vector quantity, as it has both speed and direction. The same external force applied to such a moving body will change either the speed or the direction, depending upon the relative directions of that force and of the moving body. But as force is defined as mass × acceleration, the physicist, apparently forgetting the difference between pure and applied mathematics, methodically divides this force by the mass and calls the quotient acceleration. It simplifies his mathematics.

I have quoted these remarkable sentences at length, because I should not dare to attempt any summarizing paraphrase. Assuming that the physicist is "arguing correctly" when he makes a "moving body represent a vector quantity," the offense seems to consist in "apparently forgetting the difference between pure and applied mathematics." What is this difference? It is that the "pure" mathematics is applicable to dynamical problems, whereas Dr. Hering's "applied" mathematics is not.

The case of the revolving fly-wheel offers no real difficulty either of treatment or of terminology. The "acceleration" of the fly-wheel as a whole is either a term without meaning, or applies to a translatory movement. Any point or particle of the wheel is accelerated toward the axis, from which we infer the existence of a force in this direction acting on the particle. Of the fly-wheel as a whole, we speak of the "angular acceleration," which is zero when the angular speed is constant and the direction of the axis invariable. From the vanishing of this vector we infer, not the absence of an external force, but the absence of an external torque or couple.

Take the case of a falling particle, describing a parabolic trajectory, and compare the two statements:

(*a*) The acceleration is g, vertically downward.

(*b*) The acceleration is $g \cos \theta$, where θ is the angle between the velocity and the downward vertical.

The second of these statements is in conformity with engineering usage, if I understand Dr. Hering correctly. The first statement describes the motion in such a way that if we know the velocity at any time we can

find the velocity at any subsequent time, by adding the vector gt vertically downward to the original vector velocity. The second statement assumes, so far as I can see, a knowledge of one of the quantities we need to calculate. I should very much like to see Dr. Hering's "applied" mathematics applied to this simple problem. So far as I can see, though the first statement simplifies the mathematics, the second abolishes it.

Scientific terminology is like a sharp knife used for the dissection of a problem, and unequaled for its intended purpose. It is an odd coincidence that the very number of SCIENCE which contains Dr. Hering's letter contains also an address by Dr. Gray of Edinburgh, in which the sharpness of this particular knife, the term acceleration in its strict sense, is specially noted. Dr. Hering's proposal is as if one should say, "I find your razor good for sharpening pencils, please shave with something else."

Surely the ends, neither of science nor engineering will be furthered by any such change as Dr. Hering recommends. The question is not one of simplified mathematics, but of clearness of thought.

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NOTES ON METEOROLOGY AND CLIMATOLOGY

AEROLOGICAL WORK—WINDS

AFTER the signing of the armistice had liberated much information that had been held as confidential, it became possible to assemble a group of papers on aerological work describing the pilot balloon methods used by the Weather Bureau, Signal Corps, and Navy for observing winds at various levels, and presenting the results of various lines of research.[1] The use of thousands of two-theodolite pilot balloon runs established an empirical formula for the ascensional rate of pilot balloons which tallied remarkably well with the formula derived from theoretical considerations. This formula is

$$V = 71(l/L^{2/3})^{5/8} = 71(l^3/L^2)^{.208},$$

in which V represents velocity, l the actual lifting power of the balloon ("free-lift"), *i. e.*, the weight it will support, and L the total lift (free-lift plus weight of balloon). Surprising as it is, pilot balloons ascend at a nearly constant rate, once they are above the more or less turbulent surface layer of air. Thus, single theodolite observations of angular altitude and azimuth of a balloon once a minute, when used in conjunction with the computed ascensional rate will yield reliable information as to the actual positions of the balloon, and, therefore, of the direction and velocities of the wind at all levels from the surface to the height at which it becomes lost to view. At the Aberdeen Proving Ground, temperatures for computing the densities of the air in the several altitude zones have been obtained by daily airplane ascents to a height of 10,000 feet. The score of pilot balloon stations in the United States east of the Rockies telegraph free-air wind data to the Weather Bureau in Washington twice daily, where they are used not only for aeronautical forecasting, but also as an auxiliary in making surface weather forecasts.

Meteorological kite flights are now being made at six stations daily (except when winds are light) for recording winds, relatively humidities, and temperatures aloft. The results are telegraphed to Washington daily, and later are published in *Monthly Weather Review Supplements*, where they become available for detailed investigation.[2]

The movements of dust, smoke and clouds are useful as well as balloons and kites for determining the movements of the free air. Dustfalls which occasionally occur in the northeastern United States have been traced

[1] *Mo. Weather Rev.*, April, 1919, Vol. 47, pp. 205–231. Separates of these are still available: apply to Chief, U. S. Weather Bureau, Washington, D. C.

[2] See, for instance, V. E. Jakl, "Some observations on temperatures and winds at moderate elevations above the ground," *Mo. Weather Rev.*, June, 1919, pp. 367–373. Separates of these are still available: apply to Chief, U. S. Weather Bureau, Washington, D. C.